# D E C L A R A T I O N

I, Mitsuaki MURAKAMI, a national of Japan, c/o Sumitomo Chemical Intellectual Property Service, Limited, 5-33, Kitahama 4-chome, Chuo-ku, Osaka-shi, Osaka 541-8550, Japan, declare that to the best of my knowledge and belief the attached is a full, true and faithful translation into English made by me of the certified copy of Japanese Patent Application No. 2000-272864 attached thereto.

Signed this 4th day of February, 2004

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PATENT OFFICE
JAPANESE GOVERNMENT

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[Title of the Invention] A vacuum ultraviolet radiation excited light-emitting device

[Scope of Claim for a Patent]

[Claim 1]

A vacuum ultraviolet radiation excited light-emitting device comprising a discharge space filled with a rare gas between a front faceplate and a rear faceplate, parallel disposed to each other, and a fluorescent material layer provided on the front faceplate, wherein the fluorescent material layer has a thickness of not more than 7 $\mu$m.

[Claim 2]

A vacuum ultraviolet radiation excited light-emitting device comprising a discharge space filled with a rare gas between a front faceplate and a rear faceplate, parallel disposed to each other, fluorescent material layers provided on both the front faceplate and the rear faceplate, wherein the fluorescent material layer on the front faceplate has a thickness of not more than 7 $\mu$m.

[Claim 3]

The vacuum ultraviolet radiation excited light-emitting device according to claim 2, which is a rare gas lamp.

[Claim 4]

The vacuum ultraviolet radiation excited light-emitting device according to claim 3, wherein the fluorescent material

layer on the rear faceplate has a thickness of not more than 30 $\mu$m.

[Claim 5]

The vacuum ultraviolet radiation excited light-emitting device according to claim 2, which is a plasma display panel.

[Claim 6]

The vacuum ultraviolet radiation excited light-emitting device according to claim 5, wherein the fluorescent material layer on the rear faceplate has a thickness of not more than 20 $\mu$m.

[Claim 7]

The vacuum ultraviolet radiation excited light-emitting device according to any of claims 1-6, wherein the fluorescent material layer contains a fluorescent material having an average primary particle diameter of not more than 1 $\mu$m.

[Detailed Explanation of the Invention]

[0001]

[Technical Field to which the Invention belongs]

The present invention relates to vacuum ultraviolet radiation excited light-emitting devices which are excited to emit light by vacuum ultraviolet radiation and, more particularly, to a plasma display panel (hereinafter sometimes referred to as "PDP") used as a flat panel display having a large-sized screen, and a rare gas lamp.

[0002]

[Prior Art]

The PDP as one example of the vacuum ultraviolet radiation excited light-emitting device is a flat panel display realizing upsizing of screen, which is difficult with a cathode ray tube (CRT) or a liquid crystal color display, and is expected to be used as a display installed in a public space or for a TV set having a large screen.

[0003]

Generally, PDPs have a structure described in Japanese Patent Laid-Open No. 10-142781. A pair of glass substrates are disposed generally parallel with each other, and the space between the glass substrates is partitioned with partition walls to provide a multiple discharge spaces (each hereinafter sometimes referred to as "cell") filled with a rare gas composed of Ne or Xe as a major component. Of the glass substrates, one positioned on the PDP viewer side is a front faceplate, while the other a rear faceplate. On the side of the front faceplate facing the rear faceplate are formed electrodes, a dielectric layer covering the electrodes, and a protective layer (MgO layer) on the dielectric layer. Address electrodes crossing the electrodes formed on the front faceplate are formed on the side of the rear faceplate facing the front faceplate, and a fluorescent material layer is formed so that the rear faceplate and wall surfaces of the partition walls is covered with the fluorescent material layer. When AC voltage is applied across

the electrodes to cause electrical discharge, vacuum ultraviolet radiation produced by the electric discharge causes the fluorescent material to emit light. The viewer of the PDP views visible light passing through the front faceplate.

[0004]

Besides the PDP, the rare gas lamp is also a vacuum ultraviolet radiation excited light-emitting device. The rare gas lamp is similar in structure to the PDP except that the discharge space thereof is usually not partitioned with a multiplicity of partition walls. Attention is focused on the rare gas lamp from the viewpoints of environment because the rare gas lamp does not include mercury.

[0005]

Conventional vacuum ultraviolet radiation excited light-emitting devices represented by the PDP and the rare gas lamp generally have a fluorescent material layer on the rear faceplate side in the structure described above. However, there is still a desire for development of a vacuum ultraviolet radiation excited light-emitting device exhibiting a higher luminance than the conventional vacuum ultraviolet radiation excited light-emitting devices.

[0006]

[Problem to be solved by the Invention]

An object of the present invention is to provide a vacuum ultraviolet radiation excited light-emitting device exhibiting

a higher luminance.

[0007]

[Means for solving the Problem]

The inventors of the present invention have made intensive study in order to develop a vacuum ultraviolet radiation excited light-emitting device having a higher luminance. As a result, they have found that a vacuum ultraviolet radiation excited light-emitting device including a fluorescent material layer having a thickness equal to or smaller than a specific value formed on the front faceplate exhibits a high luminance. Thus, the present invention has been completed.

[0008]

Accordingly, the present invention provides a vacuum ultraviolet radiation excited light-emitting device comprising a discharge space filled with a rare gas between a front faceplate and a rear faceplate, parallel disposed to each other, and a fluorescent material layer provided on the front faceplate, wherein the fluorescent material layer has a thickness of not more than 7 $\mu$m. The present invention provides a vacuum ultraviolet radiation excited light-emitting device comprising a discharge space filled with a rare gas between a front faceplate and a rear faceplate, parallel disposed to each other, fluorescent material layers provided on both the front faceplate and the rear faceplate, wherein the fluorescent material layer on the front faceplate has a thickness of not more than 7 $\mu$

m. Further, the present invention provides a vacuum ultraviolet radiation excited light-emitting device as above-described, wherein the fluorescent material layer contains a fluorescent material having an average primary particle diameter of not more than 1 $\mu$m.

[0009]

[Mode for carrying out the Invention]

Hereinafter, the present invention will be described in more detail.

In the vacuum ultraviolet radiation excited light-emitting device according to the present invention, the fluorescent material layer having a thickness of not more than 7 $\mu$m is provided on the front faceplate. For example, in a typical PDP, electrodes are formed on the side of the front faceplate facing the rear faceplate, a dielectric layer covers the electrodes, and a protective film (MgO film) on the dielectric layer is formed. In the vacuum ultraviolet radiation excited light-emitting device according to the present invention, the fluorescent material layer may be further formed on the protective film or, alternatively, between the dielectric layer and the protective film.

[0010]

In the vacuum ultraviolet radiation excited light-emitting device according to the present invention, The thickness of the fluorescent material layer provided on the

front faceplate is not more than 7 $\mu$m, preferably not more than 5 $\mu$m. Since in this case light emitted from the fluorescent material layer passes through the fluorescent material layer itself and is viewed by the viewer, if the thickness of the fluorescent material layer on the front faceplate is more than 7 $\mu$m, the amount of emitted light decreases when the light passes through the fluorescent material layer.

[0011]

If fluorescent material layers are provided on both the front faceplate and the rear faceplate, respectively, the luminance of the vacuum ultraviolet radiation excited light-emitting device can be enhanced further.

[0012]

In the case where the vacuum ultraviolet radiation excited light-emitting device is a rare gas lamp, the rear faceplate is preferably provided with a fluorescent material layer having a thickness of not less than 30 $\mu$m because such a rare gas lamp exhibits a further enhanced luminance.

[0013]

Alternatively, in the case where the vacuum ultraviolet radiation excited light-emitting device is a PDP, the fluorescent material layer on the rear faceplate preferably has a thickness of not more than 20 $\mu$m, more preferably not more than 10 $\mu$m. If the fluorescent material layer on the rear faceplate is too thick, the discharge space in a cell becomes

narrow, resulting in a lower luminance undesirably.

[0014]

Processes for forming a fluorescent material layer on the front faceplate or the rear faceplate include a screen printing process using a fluorescent material paste.

[0015]

A binder resin for use in such a fluorescent material paste used in the fluorescent material layer forming process may be any one of binder resins known in the art. Examples of such known binder resins include ethyl cellulose, methyl cellulose, nitrocellulose, acetyl cellulose, acetylethyl cellulose, cellulose propionate, hydroxypropyl cellulose, butyl cellulose, and benzyl cellulose.

[0016]

Examples of organic solvents for use in the fluorescent material paste include diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, diethylene glycol monobutyl ether, diethylene glycol monomethyl ether acetate, diethylene glycol monoethyl ether acetate, ethylene glycol monomethyl ether acetate, ethylene glycol monobutyl ether acetate, propylene glycol monobutyl ether, dipropylene glycol, dipropylene glycol monomethyl ether, dipropylene glycol monoethyl ether, dipropylene glycol monomethyl ether acetate, propylene glycol monomethyl ether acetate, 3-methyl-3-methoxybutanol, butylcarbitol acetate,

methoxybutyl acetate, and terpineol.

[0017]

The higher the light-transmissivity of the fluorescent material applied to the front faceplate, the more the luminance of the vacuum ultraviolet radiation excited light-emitting device is enhanced. If the average primary particle diameter of the fluorescent material is equal to or smaller than the wavelength of visible light, the fluorescent material allows visible light to pass therethrough. The fluorescent material preferably has an average primary particle diameter of not more than 1 μm, more preferably not more than 0.5 μm, most preferably not more than 0.3 μm for a higher transmissivity of light emitted from itself. The thickness of the fluorescent material layer on the front faceplate is not more than 7 μm. Since each particle of the fluorescent material needs to be considerably smaller than the thickness of the fluorescent material layer, use of fluorescent material powder having the foregoing average primary particle diameter is preferable also for the formation of the fluorescent material layer having a thickness of not more than 7 μm.

[0018]

As the fluorescent material, there can be used any one of conventionally known fluorescent materials, examples of which include $Y_2O_3$:Eu, $Y_2O_2S$:Eu, and (Y, Gd)$BO_3$:Eu as red fluorescent materials; $BaAl_{12}O_{19}$:Mn, $BaMgAl_{10}O_{17}$:Mn,

$BaMgAl_{14}O_{23}$:Mn, and $Zn_2SiO_4$:Mn as green fluorescent materials; and $BaMgAl_{10}O_{17}$:Eu and $BaMgAl_{14}O_{23}$:Eu as blue fluorescent materials.

[0019]

The provision of the fluorescent material layer having a thickness of not more than 7 $\mu$m makes it possible to realize a vacuum ultraviolet radiation excited light-emitting device, such as a rare gas lamp or a PDP, exhibiting a high luminance.

[0020]

[EXAMPLES]

Hereinafter, the present invention will be described more specifically by way of examples, which should not be construed to limit the scope of the present invention.

[0021]

EXAMPLE 1

0.0081 mol of yttrium chloride hexahydrate ($YCl_3 \cdot 6H_2O$), 0.0009 mol of europium chloride hexahydrate ($EuCl_3 \cdot 6H_2O$) and 0.45 mol of urea were added to 900 ml of pure water, and the resulting mixture was adjusted to pH 2.5 by hydrochloric acid and then allowed to stand for 24 hours. This aqueous solution was heated at 92℃ for one hour to produce a slurry, which in turn was subjected to centrifugation to give a fluorescent material precursor having an average primary particle diameter of 0.15 $\mu$m measured by TEM observation. The fluorescent material precursor thus given was calcined at 1200℃ for one

hour in atmospheric air, to afford a fluorescent material ($Y_2O_3$:Eu) having an average primary particle diameter of 0.14 $\mu$m.

[0022]

The fluorescent material thus obtained was applied onto front faceplate glass. The thickness of the resulting fluorescent material layer was 5 $\mu$m. Electrodes were formed on rear faceplate glass and a dielectric layer was formed over the electrodes. Further, the dielectric layer was covered with a fluorescent material layer having a thickness of 15 $\mu$m, which in turn was covered with a protective layer, thus providing a rear faceplate. The front faceplate and rear faceplate thus obtained were bonded together so as to define a discharge space, thereby completing a PDP. The luminance of light emission of the PDP thus obtained was 180 cd/m$^2$.

[0023]

COMPARATIVE EXAMPLE 1

A PDP was manufactured in completely the same manner as in EXAMPLE 1 except that the fluorescent material was not applied onto the front face plate glass. The luminance of light emission of the PDP thus obtained was 150 cd/m$^2$.

[0024]

[Effect of the Invention]

The present invention makes it possible to realize a vacuum ultraviolet radiation excited light-emitting device exhibiting

a high luminance and hence is very useful in industry.

[Name of Document] Abstract

[Summary]

[Subject]

There are provided a vacuum ultraviolet radiation excited light-emitting device exhibiting a higher luminance.

[Means for Solution]

A vacuum ultraviolet radiation excited light-emitting device comprising a discharge space filled with a rare gas between a front faceplate and a rear faceplate, parallel disposed to each other, and a fluorescent material layer provided on the front faceplate, wherein the fluorescent material layer has a thickness of not more than 7 $\mu$m. A vacuum ultraviolet radiation excited light-emitting device comprising a discharge space filled with a rare gas between a front faceplate and a rear faceplate, parallel disposed to each other, fluorescent material layers provided on both the front faceplate and the rear faceplate, wherein the fluorescent material layer on the front faceplate has a thickness of not more than 7 $\mu$m.

[Selected drawing] None

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